Import Competition and Employment Dynamics

Hâle Utar*†

This version: May 10, 2008

Abstract

In order to quantify the effect of foreign competition in domestic industries and to elucidate the cross-country differences that have been observed in response to intensified import competition, this paper presents and estimates an open industry model under monopolistic competition and aggregate uncertainty. It provides a novel method for rigorously characterizing how firms adjust to intensified import competition and aggregate shocks in a structural framework. In the model, heterogeneous firms face competition both from outside the country through imports and from inside the country in the domestic market. Firms react to changes in the competitive environment through both hiring and firing on the intensive margin and entry and exit on the extensive margin. Plant-level panel data are used to estimate the model's parameters, including the sunk start-up costs faced by new firms, fixed per period costs, the stochastic process that governs firms' idiosyncratic productivity shocks, and the adjustment costs associated with changing employment levels. Then, with the estimates of the structural parameters, the model is used to characterize and quantify the effects of intensified import competition on job turnover patterns, productivity distributions, and entry and exit patterns of the firms. The model also characterizes the interactions among intensified import competition, labor market regulation and exchange rate regime. Thus it elucidates the cross-country, cross-industry differences that have been observed in response to heightened import competition. The model predicts the associated changes in aggregate productivity, employment, job flow patterns and mark-ups in the new long-run equilibrium as well as the nature of the transition process when openness changes, and the role of adjustment costs in shaping firms' behavior.

KEYWORDS: Industry Dynamics, Monopolistic Competition, Aggregate Uncertainty, Import Competition, Job Creation and Job Destruction

*Department of Economics, University of Colorado at Boulder, email:utar@colorado.edu

†This paper was funded by NSF grant SES 0617888. I gratefully thank James Tybout and Edward Green for fruitful discussions. I thank John Haltiwanger and John McLaren for their very detailed and insightful discussion of the paper. Thoughtful comments from Nezih Guner, Barry Ickes, Wolfgang Keller, Mark Roberts, Neil Wallace, Stephen Yeaple are acknowledged with appreciation.

1 Introduction

Studies looking at inter-industry job reallocation after trade liberalization episodes have found insignificant reshuffling of resources *between* industries.[1] On the other hand, studies using micro-level data have found substantial reshuffling of resources *within* narrowly defined industries in the immediate aftermath of trade liberalization episodes.[2] These findings imply that intra-industry firm heterogeneity is an important dimension of response to openness. Thus, quantification of job flows and productivity in response to intensified import competition requires modeling a firm-level adjustment in an industry with heterogeneity.

This paper presents a structural model that is developed to capture evolution of a single industry facing foreign competition under monopolistic competition and aggregate uncertainty. Plant-level panel data are used to estimate the model parameters. With the estimated parameters, the model characterizes the new long-run equilibrium that results from intensified import competition in terms of patterns of job flows, entry and exit, productivity, size and mark-up distributions, as well as the transitional dynamics and the net changes during the transitionary periods. The model also characterizes the interactions among intensified import competition, labor market regulation and exchange rate regime. Thus it elucidates the cross-country, cross-industry differences that have been observed in response to heightened import competition.

Opening up to international trade may alter the patterns of resource reallocation among heterogeneous plants and may cause increased aggregate productivity and/or increased uncertainty about the persistence of jobs in the labor market. On the other hand, the flexibility of the labor market is an important factor in achieving efficient allocation of resources. Many developing countries have heavy regulations on the labor market. Additionally the nature of firm-level adjustment to trade policy critically depends on the entry costs that potential entrants face and exit costs that incumbent firms are subject to. The model developed in this paper can be seen as part of the empirical literature, which is based on structural models and quantifies 'deep' parameters of the industry that affect firms' adjustment to trade policy.[3] In this paper, I quantify the extent of firing frictions,

[1] See for example Wacziarg and Wallack (2004).
[2] See for example Tybout and Westbrook (1995) and Pavcnik (2002).
[3] See for example Das, Roberts, and Tybout (2007).

entry and exit frictions as well as the effect of these frictions on the response of an industry to a change in the trade regime.

In the model, heterogeneous firms face competition both from the outside through imports and from the domestic market. Domestic incumbent firms' firing decisions are subject to adjustment costs, and potential entrants' entry decisions are subject to start-up costs. In addition, real wages and imports prices evolve stochastically according to exogenous processes.[4] As the processes that drive real wages and import prices unfold, and as individual firms realize their productivity shocks, the set of active producers and their employment levels respond. Each firm owner behaves optimally, given his beliefs about the exogenous processes and the behavior of his competitors. In equilibrium, each firm owner's beliefs are consistent with the actual behavior of all others.

This is the first paper that solves and estimates an industrial evolution model under monopolistic competition and aggregate uncertainty and so provides a novel tool to quantify the impact of macroeconomic uncertainty and trade policy changes on firms behavior. This model allows for imperfect competition and variable mark-ups. Toughness of competition, which is measured by the average price and the number of competitors, is endogenous in the model. It evolves endogenously in response to the decision of incumbent firms and new entrants. It also evolves in response to exogenous aggregate shocks. Then it feeds back into the decision of incumbents and entrants. Similarly, aggregate shocks affect firms behavior both directly through exogenous changes, and indirectly through their impacts on endogenous industry-wide state variables.

This model builds on Hopenhayn (1992) with a differentiated demand system and introduces foreign competition in the product market as well as aggregate uncertainty. Given the presence of aggregate uncertainty and imperfect competition, computation and estimation of this model are not straightforward because of the well-known problem related to the large numbers of state variables.[5] To overcome this problem I solve for an approximate equilibrium in which the industry-wide endogenous state variables follow a Markov process that is consistent with individual firm behavior. This approach is motivated by the recent literature on models with heterogeneous agents in which distributions are approximated by their finite moments (Krusell and Smith, 1998). The model de-

[4]Demand fluctuations are typical in small developing countries like Colombia.

[5]As the number of dimensions of the state variable increases, the amount of time and space required to compute the solution to a continuous dynamic programming problem increases exponentially.

veloped in this paper is the first paper to use this solution methodology to compute monopolistically competitive industrial evolution model.

Applied to the Colombian metal products industry, the estimates of the key parameters are very plausible. First, sunk entry costs amount to about 90 per cent of the average value of capital. These are the costs associated with starting up a business, such as government-imposed legal expenses, installation, customization costs, and product development. Second, per-period fixed costs are estimated to be about 25 per cent of the average value of capital in the industry. The average scrap value of exiting firms is estimated to about 14 percent of the average value of capital in the industry. Given the small scale and relatively low capital intensity of the industry, this estimate seems plausible. Finally, firing costs amount to about 3 months wages. During the sample period, Colombian law mandated seniority payments upon separation amounting to one month's wage per year worked, based on a salary at the time of separation.

The preliminary simulation results based on these parameters show that switching to a more liberal trade regime is associated with a significant reduction (about 18 %)in the number of jobs in the short-run. This is consistent with the findings of previous econometric studies (e.g. Freeman and Katz 1991). A substantial fraction of the total reduction in jobs is due to net exit as the number of active firms also drops by roughly 11 percent. Thus the model provides a structural explanation for the stylized fact that significant job destruction takes place on the entry/exit margin, and it suggests that studies based on panels of continuing firms are likely to miss a fundamental type of job flow. There are also productivity gains associated with the switch to a more liberal trade regime because of the reallocation effect especially through exit. More precisely, un-weighted productivity increases 0.079 log points and size-weighted productivity increases by about 0.004 log points on average. This, too, is consistent with econometric studies, which show productivity gains in the aftermath of a trade liberalization due to the exit of inefficient plants (e.g., Pavcnik, 2002)

Preliminary simulation exercises also show that the covariance between size and productivity decreases by about 16 percent in the first 10 years of the transition to heightened import competition. This is because estimated macro regime associated with relatively open period in Colombia exhibits lower persistence and lower persistence cause larger inaction band as firms perceive jobs created today will less likely be here tomorrow. Lowering firing costs from 3 months wages to 2 months wages improves the relationship between size and productivity by about 2.2 per cent in the short-run, while the improvement is about 2 percent in the long run with an about 2 percent increase in the total number of jobs. These results altogether establish that the external conditions play an important role in the response of the industrial sector to the changes in trade policy.

1.1 Related Literature

Numerous reduced-form studies have investigated the link between increasing foreign competition and domestic labor market. Increasing foreign competition in these studies indexed by exchange rates, the volume of exports and imports, and trade policies such as tariffs and quotas.

Some analysts describe patterns of association using industry-level data and conclude that employment declines with the increase in import competition.[6] Similar conclusions emerge from studies using gross flows data to look for the effects of job creation and destruction.[7] Focusing on production rather than jobs, Bernard, Jensen and Schott (2005) document patterns of correlation between import penetration rates and industry-specific rates of plant survival and growth.[8] This paper contributes to this literature by making it possible to deal correctly with the interaction between trade policy and macroeconomic shocks.

Pavcnik(2002) points out the significance of reallocation effects in accounting for growth in productivity in the Chilean manufacturing sector following trade liberalization. She aggregates productivity levels across plants in a given industry and finds that market share reallocation from less to relatively more productive units accounts for about 2/3 of the total productivity gain. Similar conclusions also emerge from Bernard, Jensen and Schott (2003) in their study using U.S. plant-level

[6] Freeman and Katz (1991), Revenga (1992), and Sachs and Shatz (1994).

[7] For example, Kletzer (1998, 2000) regresses industry-specific worker displacement rates on import-penetration rates, Davidson and Matusz (2003) regress job creation and destruction data on sector-specific foreign trade indices.

[8] Other empirical studies analyze the effect of exchange rate fluctuations and tariff reductions on the net employment fluctuations and gross job flows in firm-level econometric studies. Klein, Triest and Schuh (2003) analyze the impact of the real exchange rate movements on gross job flows using establishment level panel data. They find that changes in the trend of the real exchange rate affect reallocation but not net employment. Gourinchas (1999) uses firm level data, and finds that exchange rate appreciation reduces net employment growth as a result of lower job creation and increased job destruction. On the other hand, Bentivogli and Pagano (1999) find a limited effect of exchange rate fluctuations on job flows for a number of European countries.

data.

Motivated by empirical findings, recent theoretical trade models have departed from representative firm assumption and provided a framework to explain the productivity gain through market share reallocation among continuing firms as well as entry and exit. (e.g. Melitz, 2003 and Melitz and Ottaviano, 2005) The model developed in this paper empirically elaborates the above mentioned recently emerged trade models with heterogeneous firms in terms of productivity operating in an imperfectly competitive industry of horizontally differentiated products. The model developed here differs from those studies by giving insight into the the long-run equilibrium under aggregate uncertainty. Another difference is that this study focuses on the effect of the import competition in the product market by abstracting from exporting behavior.[9]

My paper focuses on the intra-industry selection processes, instead of between sectoral differences and comparative advantage effect. Another way of studying the effect of openness on job flows is to focus on inter-sectoral job reallocation based on search theory in a general equilibrium set-up. Davidson, Martin and Matusz (1999) investigate the implications of labor market turnover on international trade patterns in a general equilibrium model of trade where jobs are created and destroyed at exogenous rates. They consider two symmetric countries in terms of endowment and production technology. Then the labor turnover becomes an independent determinant of comparative advantage and determines the trade pattern between the two countries. Chaudhuri and McLaren (2003, 2004) develop a dynamic trade model where workers are subject to moving costs. Similarly, Kambaurov (2003) analyzes the effect of firing taxes in inter-sectoral labor mobility in a general equilibrium competitive search model.

Finally, without looking explicitly at trade issues, some analysts have developed structural models that describe the dynamics of job creation and destruction in the presence of adjustment costs. This literature is particularly relevant because it deals with uncertainty, and in some cases, firm heterogeneity. Bentolila and Bertola (1990) develop a partial equilibrium labor demand model of a monopolist that faces a stochastic demand function and asymmetric hiring and firing costs. They find that firing costs do not have a large effect on hiring decisions, and that high firing

[9] Although exporting is an important source of the self-selection mechanism, incorporating export will be a future research agenda.

costs do not reduce the average level of employment. Hopenhayn and Rogerson (1993) develop a general equilibrium model with endogenous entry and exit, competitive product markets and no aggregate uncertainty. In contrast to Bentolila and Bertola (1990), they find that severance costs equal to one year's wages decrease average employment levels by about 2.5 percent. Veracierto (2001) introduces a flexible form of capital into Hopenhayn and Rogerson's framework and studies the short-run effects of the severance cost. He finds that incorporating capital does not affect the long-run consequences of severance payment, but creates differences in the short-run depending on the elasticity of substitution between the two inputs.

The remainder of the paper is organized as follows: Section 2 and Section 3 respectively introduce the model and the methodology that is used to solve the model. As this model is applied to Colombian metal products industry, Section 4 introduces the environment that surrounds this industry. In Section 5 the estimation methodology and the estimation results are presented. Finally Section 6 presents and discusses a few simulation experiments that I conducted to assess the effect of openness with focus on the role of expectations in shaping firms' responses and the role of labor market policies. Concluding remarks follow in Section 7.

2 The Model Overview

Assume that agents are infinitely lived and make their choices in discrete time. Each period, the economy consists of a number of monopolistically competitive heterogenous domestic producers and a number of potential entrants. Each firm is assumed to produce a uniquely differentiated variety and faces a downward sloping demand function. The demand function depends on the firm's own price, the average price in the industry, and the number of varieties currently produced.[10]

The demand function for each firm is derived from the quasi-linear preferences of a representative consumer,who values varieties equally regardless of whether they are domestically produced or imported. As a result, the demand schedule for domestic producers depends on the number and prices of imported varieties since these affect the total number of varieties and the average price.

[10]This is monopolistic competition in the Chamberlin sense where firms consider themselves too small to affect the industry aggregates.

It is assumed that imported goods' prices move stochastically over time. Domestic producers take this stochastic process as given.

At each point in time, an incumbent firm's operating profits depend on several firm-specific variables: its current productivity level, its current employment, and its previous period employment. The latter variable matters because the firm faces firing costs. Each firm's profits also depend on two endogenous market-wide variables: average output prices for domestically-produced varieties and the number of domestic producers. Finally current profits depend upon two exogenous market-wide variables: wages, and the average price of imported varieties, which in turn depends upon trade policy and the exchange rate.

Note that it is not necessary to know the joint distribution of firms in order to calculate a firm's current profits; knowing average prices and the number of market participants is sufficient. Nonetheless, it is necessary to keep track of this distribution because the transition density for average prices and numbers of participants in the industry depends upon the evolution of the number of firms in each individual state.

In addition to incumbents, the model also describes the behavior of potential entrants. These firms are identical up to the entry costs that they draw. Once they observe these costs, they compare them with the expected value of being an incumbent next period. When the expected value of being an incumbent is higher than the entry cost, they decide to enter the industry. Following the entry decision, entrants draw their initial productivity realization from a commonly known distribution, and start to produce the next period.

For any period, the sequence of actions is as follows. First, before the realization of firm-specific and aggregate shocks, last period's incumbents who decided to exit pay their labor adjustment cost and receive their firm's scrap value, and exit. Then, both incumbents and potential entrants observe the current realization of aggregate shocks. Given the aggregate state of the economy and their individual states, incumbent firms make their employment decisions. Finally, potential entrants decide whether to enter or stay out for the next period. Those that enter draw their productivity and join to the next period's incumbents.

Given this setting, different firms have different reactions to common industry-wide shocks. One reason is that different firms face different demand elasticities and have different probabilities of exit. The response of firms facing higher demand elasticities will be more sensitive to the shocks. Due to policy distortions (firing costs) industry-wide response will also differ across positive and negative shocks depending on the current distribution of firms. It will be more costly for larger firms to contract or to exit in response to negative shocks.

It is important to note at this stage that the evolution of the firm distribution is not trivial in this economy. At any point in time, the economy will be populated by incumbents that differ in their current productivity shocks and past employment. Given aggregate variables and aggregate shocks, each producer will decide on its current employment and its entry/exit decision for the next period. These decisions together with the entry of new firms will determine the distribution of incumbents next periods. Hence, although an individual firm is only concerned about the evolution of industry aggregates, the way these aggregates evolve reflects individual decisions.

Methodologically, this paper is in the spirit of Krusell and Smith (1998), who find that a Markov process for the mean of the wealth distribution is enough to approximate the equilibrium in a stochastic growth model with heterogeneous households.[11] I compute the equilibrium by assuming that agents forecast the evolution of the aggregates using a technique similar to Krusell and Smith's (1998). That is, for each different realization of aggregate shocks, firms forecast stochastic evolution of the industry aggregates which is consistent with firms' optimal decisions.

2.1 Production and Costs

Each firm has access to the same production technology, up to a firm-specific productivity shock. The firms' only input is labor. Firm i's production technology is given by

$$f(l) = e^{\mu_{it}} l_{it}^{\theta}, \qquad 0 < \theta \leq 1, \tag{1}$$

where l_{it} denotes labor input, and μ_{it} is the firm-specific productivity shock. The firm-specific productivity shock is assumed to follow a first order $AR(1)$ process given by

[11] Similarly Khan and Thomas (2003) in their paper which analyzes the role of nonconvex adjustment cost in aggregate investment dynamics in a stochastic general equilibrium model finds it is enough to approximate the equilibrium close enough using only the two moments of the distribution of plants over capital and productivity.

$$\mu_{it} = a_0 + a_1\mu_{it-1} + \varepsilon_\mu, \qquad \varepsilon_\mu \sim N(0, \sigma_\mu^2). \tag{2}$$

The transition density for the productivity is denoted by $M(\mu_{it+1}|\mu_{it})$.. These idiosyncratic shocks are independent across firms, but, for any individual firm the shock evolves according to the transition function M.

In each period t, firms pay w_t for each unit of labor that they employ. It is assumed that there is a perfectly elastic supply of labor and firms behave as price takers in the factor market. In addition to the unit cost of labor,w_t, firms incur a firing cost, c_f, per dismissed job.[12] Firms also pay a fixed per period cost f.

2.2 Demand

The demand side of the product market is characterized by the quasi-linear preferences of a representative consumer over horizontally differentiated varieties $q_i, (i \in \{1, ..N\})$, and a numeraire good, q_o. The utility function of a representative consumer is given by

$$U(q_o, q_1, q_2, .., q_N) = q_o + \alpha \sum_{i=1}^{N} q_i - \frac{1}{2}\gamma \sum_{i=1}^{N} q_i^2 - \frac{1}{2}\eta (\sum_{i=1}^{N} q_i)^2. \tag{3}$$

This utility function has been previously used by Ottaviano, Tabuchi, Thisse (2002) and Melitz and Ottaviano (2004). As opposed to CES type of utility functions it allows the price elasticity of demand to vary with respect to average price and the number of differentiated goods. That is, it allows to keep the competition channel of trade open and leaves room for an operation of the link between labor demand and product demand elasticities. The parameters α, γ, and η are all positive. Parameters α and η index the degree of substitution between the varieties and the outside goods, that is, they shift the industry demand curve relative to the outside good, while γ indexes the degree of product differentiation among the varieties.[13]

[12] In data, I only observe net changes in employment rather than worker flows. That is firing costs will capture more than severance payments upon seperation per dismissed employee.

[13] The varieties in the demand system are treated symmetrically. That is, there is no product appeal but the variations come from differences in productivity levels. In principle, it is possible to adjust the demand system to allow for product appeal as in Foster, Haltiwanger and Syverson (2007).

Utility maximization gives the demand for each variety q_i as,

$$q_i = (\frac{\alpha}{\eta N + \gamma} - \frac{1}{\gamma} p_i + \frac{\eta N}{\eta N + \gamma} \frac{1}{\gamma} \overline{P}). \tag{4}$$

where $\overline{P}$ is the average price of all differentiated varieties.[14] This specification of demand implies a maximum price

$$p_{max} = \frac{\gamma \alpha + \eta N \overline{P}}{\eta N + \gamma}$$

above which demand is zero.

The number of varieties produced domestically is denoted by N_D, and the number of imported varieties is denoted by N_F, i.e. $N = N_D + N_F$. Hence

$$\overline{P} = \frac{N_D \overline{P}_D + N_F \overline{P}_F}{N_D + N_F}, \tag{5}$$

where $\overline{P}_D$ denotes the average price among the domestic varieties and $\overline{P}_F$ denotes the average price of imported varieties.

2.3 Aggregate States

Three exogenous aggregate shocks that appear in this model are real wages, w_t, the average price of imported varieties, $\overline{P}_{F,t}$, and the number of imported varieties, $N_{F,t}$.

The number of imported varieties are assumed to be iid,[15]

$$N_{F,t} = \overline{N}_F + \varepsilon_t, \quad \varepsilon_t \sim N(0, \sigma_\varepsilon^2). \tag{6}$$

The average price of imported varieties, $\overline{P}_{F,t}$ and the wages, w_t, are summarized by a vector $s_t = (\overline{P}_{F,t}, w_t)$, and they jointly evolve according to a first order Markov Process. The associated transition density is denoted by $\Phi(s_{t+1}|s_t)$. It is assumed that, s_t is independent of ε_t. Finally, let Γ_t be time-t distribution of incumbents over their idiosyncratic productivity shocks and last period's employment levels.

[14] Inverse demand can be expressed as $p_i = \alpha - \eta N \overline{q} - \gamma q_i$ where $\overline{q}$ is the average quantity among all differentiated varieties.

[15] The shocks to the number of foreign varieties can also be interpreted as iid demand/taste shocks. This assumption can also be justified by assuming fixed costs for exporting and negligible share of the industry in the global economy.

2.4 Incumbents' Decision Problem

The current state of an incumbent firm is given by its current productivity shock μ_{it}, its last period's employment l_{it-1}, aggregate shocks s_t and Γ_t. Incumbents' problem is to choose the price and the associated level of employment imposed by the technology and the exit decision for the next period. Let $\Gamma_t = H(\Gamma_{t-1}, s_t)$ be a transition function that maps last period's distribution and current aggregate shocks to current distribution. The function H reflects firm-level decisions and will be correctly understood by all agents in equilibrium. Given m, Φ, and H each incumbent has a well-defined problem characterized by the following Bellman equation,

$$\begin{aligned} V(\mu_{it}, l_{it-1}; \Gamma_t, s_t) &= Max_{l_{it}} P_i(\overline{P}(\Gamma_t), l_{it}, \mu_{it}) e^{\mu_{it}} l_{it}^{\theta} - w_t l_{it} - c(l_{it}, l_{it-1}) - f \\ &\quad + \beta Max(EV(\mu_{it+1}, l_{it}; \Gamma_{t+1}, s_{t+1} | \mu_{it}, s_t), -c(0, l_{it}) + x(l_{it})) \end{aligned} \tag{7}$$

subject to

$$\Gamma_{t+1} = H(\Gamma_t, s_{t+1}),$$

and

$$c(l_{it}, l_{it-1}) = Max\{0, c_f(l_{it-1} - l_{it})\}.$$

[16]

Here $P_i(\overline{P}(\Gamma_t), l_{it}, \mu_{it})$ denotes the inverse demand function that a firm faces as it is determined by equation (4) and $x(l)$ denotes the scrap value which is assumed as a function of firms' size. I make use of the fact that firm's output, q_i, will be a function of μ_{it}, l_{it}, and Γ_t. This optimization problem will generate two policy functions, one for employment,

$$l_{it} = e(\mu_{it}, l_{it-1}; \Gamma_{t-1}, s_t) \tag{8}$$

[16]Notice that this specification of firing costs imply an inaction band in which firms do not adjust the level employment. However, once adjustment decision is made, they will choose the optimal level of employment implied by the current profit function.

and one for the exit decision

$$\chi(\mu_{it}, l_{it-1}; \Gamma_t, s_t) = \begin{cases} 0 & if \quad EV > -c(0, l_{it}) \\ 1 & otherwise \end{cases} \tag{9}$$

For a given $(\Gamma_t, s_t, l_{it-1})$, the exit decision χ will give a cut-off level of productivity $\mu_{it} = \mu^*$ below which the firm will choose to exit.

2.5 Potential Entrants' Decision Problem

Each period, there is an exogenous pool of $\overline{R}$ ex-ante identical potential entrants. Entrants pay their sunk entry cost, F, before entering the market. At the beginning of each period, each potential entrant draws its entry cost from a commonly known distribution, denoted by $\Psi(F)$ with positive support on $[F_L, F_H]$.

Upon drawing an entry cost, each potential entrant decides whether to enter the market next period and pay the entry cost. Once the entry decision is made, entrants draw their productivity from a commonly known distribution denoted by $M_0(\mu)$. Potential entrants make their entry decisions given the current market states, given the transition density for the initial productivity draws. Given an incumbent's problem defined in (7), each potential entrant's problem is given by

$$V^E(\Gamma_t, s_t | M_0) = \beta EV(\mu_{i,t+1}, 0; \Gamma_{t+1}, s_{t+1}) \tag{10}$$

subject to

$$\Gamma_{t+1} = H(\Gamma_t, s_{t+1})$$

It is assumed here that potential entrants enter with the level of employment which maximizes their expected value.

Potential entrants will choose to enter if

$$V^E(\Gamma_t, s_t | M_0) > F. \tag{11}$$

Condition (11) determines the number of entrants, denoted by

$$\Xi_t = \Psi(V_t^E)\overline{R}. \tag{12}$$

2.6 Equilibrium

Given M, M_0, Φ, Ψ, and H an equilibrium is a value function V for incumbents, a value function V^E for potential entrants, and a set of decision rules $e(.)$, $\chi(.)$, and $\Xi(.)$ such that

1. Given M, Φ, and H each incumbent solves (7) and the resulting decision rules are given by $e(.)$ and $\chi(.)$.
2. Given V, H, and M_0, V^E characterizes the problem of potential entrants.
3. H is consistent with firm's optimal decision rules.

3 The Methodology to Solve the Equilibrium:

Since there is no close form solution for the model described above, numerical methods are employed to solve for an equilibrium. Further, numerical solution of this model is quite cumbersome because the distribution of incumbent firms across past level of employment and current values of the idiosyncratic productivity shock, Γ_t, are endogenous aggregate state variables. That is, firms have to keep track how this distribution evolves over time. Because evolution of this distribution generates the evolution of endogenous industry aggregates. To overcome the problem of this dimensionality, I use a solution technique which is in the spirit of Krusell and Smith (1998). The idea is to use a finite set of moments of the distribution when forecasting future endogenous industry aggregates.

Let m_t be a vector of the first I moments of Γ_t, i.e.,

$$m_t = m_{1t}, m_{2t}, .., m_{It}$$

.

The solution method uses a class of functions H_I which express the vector I moments for the next period, m_{t+1}, as a function of the current I moments, m_t, i.e.

$$m_{t+1} = H_I(m_t, s_t)$$

I use the fact that an individual firm is concerned only with the exogenous aggregate shocks, s_t, and with two endogenous industry aggregates, the number of producers $N_{D,t}$, and the average price $\overline{P}_{D,t}$. That is, because of the monopolistically competitive market structure, firms only need to know the evolution of endogenous industry aggregates/moments. Let m_t denote these industry aggregates/moments and the other moments of the distribution. Then, we can define the following dynamic programming problem for an incumbent:

$$\begin{aligned} V(\mu_{it}, l_{it-1}; m_t, s_t) = Max_{l_{it}} P_i(m_t, l_{it}, \mu_{it}) e^{\mu_{it}} l_{it}^{\theta} - w_t l_{it} - c(l_{it}, l_{it-1}) - f \\ + \beta Max(EV(\mu_{it+1}, l_{it}; m_{t+1}, s_{t+1} | \mu_{it}, s_t), -c(0, l_{it}) + x(l_{it})) \end{aligned}$$

subject to

$$m_{t+1} = H_I(m_t, s_{t+1}),$$

and

$$c(l_{it}, l_{it-1}) = Max\{0, c_f(l_{it-1} - l_{it})\}.$$

We can redefine the potential entrants' problem in a similar fashion.

In this alternative formulation, agents only use the information provided in H_I. The optimal decision rules resulting from this alternative formulation are used to generate time series data for the I moments of the distribution.

Although an individual firm is only concerned with s_t and m_t and how these evolve over time, at any point in time the economy is characterized by a distribution of incumbents over their firm-specific productivity shocks and the last period's employment levels.

The approximate equilibrium is solved using the following algorithm:

1. Choose the moments of the distribution Γ

2. Assume functional forms for H_I and guess on the parameters for that functional form

3. Given H_I, solve the incumbents' and potential entrants' optimization problems.

4. Use the resulting decision rules, simulate the industry over a long period, and generate the time series for the evolution of $\overline{P}_t$ and N_t. and other set of moments. In order to simulate the economy, start with an initial Γ_0 and m_0. Using the optimal decisions update Γ_t for $t > 0$.

5. Use the stationary region of the time series to update the parameters of the H_I.

6. Check if the updated and previous set of the parameters of the H_I are sufficiently close, if not return to step 3. Continue iterating on the function parameters until a fixed point is found.

7. If the goodness of fit of the estimated parameters is satisfactory, then an equilibrium has been reached. If the goodness-of-fit is not satisfactory then moments can be added to m_R or a different functional form of H_I can be tried.

3.1 Goodness-of-Fit

I use log-linear functional form and $m_t = \begin{bmatrix} \overline{P}_t & N_t \end{bmatrix}$ and s_t as aggregate state variables. The law of motion for average price can be written as

$$\ln \overline{P}_{D,t+1} = a_0 + a_1 \ln \overline{P}_{D,t} + a_2 \ln N_{D,t} + a_3 \ln \overline{P}_{F,t+1} + a_4 \ln w_{t+1}$$

where R^2 which is the goodness-of-fit for the regression is on average 0.9725.

The law of motion for the second moment, number of operating firms, can be written as

$$\ln N_{D,t+1} = b_0 + b_1 \ln \overline{P}_{D,t} + b_2 \ln N_{D,t} + b_3 \ln \overline{P}_{F,t+1} + b_4 \ln w_{t+1}$$

and the associated R^2 is on average 0.9709.

As can be seen from the goodness-of-fit statistics, the model performs well in terms of the number of moments chosen and the functional form of the law of motion. It is worth to note, at this point, that the stationary environment of the model restricts types of the distribution, Γ, than can occur in an equilibrium. This facilitates the solution algorithm.

4 Environment of The Colombian Metal Products Industry

The model is estimated using data from Colombian structural metal product industry (SIC 3813) for the period 1977 through 1991. Colombia is a small open developing country that has experienced significant swings in its foreign trade and exchange rate policies. Accordingly, it provides a natural candidate to study the firm-level consequences of trade related shocks. In this section, I describe the Colombian structural metal product industry and the macroeconomic environment surrounding this industry.

At the beginning of the sample period, Colombia had a fairly liberal trade environment. In 1980, the average nominal tariff on manufacturing goods was about 26 per cent, and almost 70 per cent of all commodities did not require import licensing.[17] However, the level of protection has been increased after economy suffered a severe macroeconomic crisis in the early 80s. In 1984, 83 percent of all commodities required licences, and imports of some products were prohibited. The evolution of the nominal tariff rates and import prices for this industry is given in Figures 1 and 2. The 1983-1985 period can be easily recognized in these figures. In 1984, the nominal tariff rates for the industry reaches 45 percent. Together with trade liberalization in 1991, these policy changes in the period between 1991-1998 are a source of identification for regime-switching VAR process that is presented in section 5.1. During the sample period, i.e. from 1977-1991, the average nominal tariff for the 4-digit metal products industry was about 30 per cent. Average nominal tariff rates fell to 19 per cent with the trade reforms in 1991.

4.1 Labor Market

The Colombian labor market can be considered rigid during the sample period. The main components of labor regulation that imposed non-wage labor costs include advance notification, indemnities for dismissal, social security contributions and seniority payments. Employers were mandated to pay seniority payments which amounted to one month salary per year worked based on the salary at the time of separation. Workers had the rights to advance payments of the amount they would potentially receive in case of a job break, with the restriction that the advance payments be

[17] For a more detailed discussion of the trade environment of the country, see Fajnzylber and Maloney (2000).

used for education or housing. In case of a job break the advanced amounts were subtracted from the severance payment in nominal, not real, terms. In the case of a voluntary quit, employers still were required to pay seniority premium. That is, seniority payments were mandatory in addition to costs of indemnities for dismissal.[18] Colombia reformed its labor codes in 1990. After 1990, the fixed cost of firing were replaced with a monthly contribution to a capitalized fund, which would be accessible to the worker only in the case of separation. Moreover, it eliminated the additional cost implied by the legislation that seniority pay was based on the salary at the time of separation rather than on the current salary. In addition, the 1990 reform widened the legal definition of 'just cause' dismissals to include economic conditions.[19]

In order to be able to talk about job flows in the sample data, I need to introduce some notation. Let L_t be the total employment in the industry at period t. Let E_{t-1} and E_t be the total number of employees in all expanding incumbent plants for the period $t-1$ to t, and similarly, let C_t and C_{t-1} be the total number of employees in all contracting plants. Finally, let B_t be the total number of employees in all entrants at period t, and let D_t be the number of employees in all exiting plants. Then the net employment growth, $(\frac{\Delta L_t}{L_{t-1}})$, can be decomposed into four parts,

$$\frac{\Delta L_t}{L_{t-1}} = \left(\frac{E_t - E_{t-1}}{L_{t-1}} + \frac{B_t}{L_{t-1}}\right) - \left(\frac{C_{t-1} - C_t}{L_{t-1}} + \frac{D_{t-1}}{L_{t-1}}\right),$$

where the first bracketed term is job creation rate, and the second bracketed term is job destruction rate. Job creation has two sources: job creation that comes from expanding plants $(E_t - E_{t-1})$, and that comes from entrants (B_t). Similarly, job destruction has two sources: from contracting plants, $(C_{t-1} - C_t)$ and from exiting plants, (D_{t-1}). The summation of these four components is called the gross job flow.

Due to the homogeneous labor assumption in the model, in the sample counter-part of job flows calculations , I use quality adjusted labor as defined in

$$l_{q,j} \equiv \frac{W_j}{w}$$

[18]Seniority payments only exist in Latin America. See Heckman and Pagés (2003) for comparison of labor laws in different countries.

[19]See Kugler (2005) and Heckman and Pages (2000) for more details on the labor market regulations in Colombia.

and

$$w \equiv \frac{\sum_j W_j}{\sum_j L_j}$$

where W_j denotes total wage payment of firm j; L_j denotes the total number of workers. To the extent that wage differences among workers reflect quality differences, by using adjusted measure of labor, l_q, instead of the number of workers in calculation of the sample moments, I take into account the differences in quality of workers. However, aggregate demand shocks are one of the important determinants of wage variation through time, especially in small developing countries. In order to isolate those demand side variations, I use the overall average of wages in calculating quality adjusted measure of labor, rather than year by year average.

Table 2 shows evolution of the four components of the job flows in the data and Table 3 shows the gross and net flows. I use quality adjusted labor in these calculations, however, patterns of job flows prepared by using raw labor measure is quite similar. Furthermore, a few plants have been observed as entering and exiting multiple times during the sample period and have been excluded in these calculations.[20] The first thing to notice is that both net and gross employment flows fluctuate significantly. Gross job flows are also very large, averaging about 35 percent during the sample period. Furthermore, gross job flows from entry and exit dominate those from expansion and contraction in almost half of the sample years. So the data confirm that gross job flows are significantly influenced by the patterns of entry and exit of plants, therefore it is preferable to build a model based on entry and exit decisions of firms.

In the model idiosyncratic productivity shocks are responsible for simultaneous job creation and destruction because aggregate shocks affect each establishment in the same direction. However, notice that response of establishments to aggregate shocks will be different for firms with different productivity levels because elasticity of demand that they face will be different. In addition due to firing restrictions, past year's employment level will be an additional source of heterogeneity even for firms with the same level of productivity.

[20] Two matching algorithms have been used in the Colombian data in order to identify the plants through time. I have used the most strict one.

4.2 Industry Structure

The metal products industry is an import-competing industry consisting mainly of small scale firms.[21] On average there are about 160 plants during the sample years, producing a range of metal products such as metal door handles, window frames, bolts, metal curtain walls, etc. These products are mainly used in construction. The assumption of horizontal differentiation is especially suitable for the metal fabrications used in architectural design, such as metal curtain walls or door handles. Although more structural metal fabrications such as metal sheets and bolts have similar standards, differences in locations between the plants provide one dimension of differentiation.

On average, the plant turnover rate was about 22 percent per annum, and new entrants accounted for about 15 percent of the total output. High entry and exit rates suggest low barriers to entry, and thus support the assumption of monopolistic competition. The industry also exhibits very significant import penetration rates during the sample period. Table 1 reports the ratio of the total value of imports to total domestic consumption, i.e. $\frac{IM}{Q-X+IM}$, where Q, X, and IM denote the value of domestic production, the value of exports and the value of imports, respectively. Notice that in contrast, the export-orientation rate $\left(\frac{X}{Q-X+IM}\right)$ is quite low which allows me to ignore the export decision of firms in the model.

5 Estimation

The model described above involves two types of parameters—those that can be identified with macro data alone, and those that must be estimated with plant-level panel data. The estimation process thus involves two stages. First, I estimate a regime-switching VAR process for the exogenous macro variables, then I estimate all of the remaining parameters using the indirect inference method. Details are provided below.

[21] The average number of employees was 36 during the sample years.

5.1 Estimation of Aggregate Shocks

Changes in trade policy affect firms within an industry by affecting the evolution of prices of the imports they compete with, and by affecting the evolution of factor prices they face. The first task is to estimate the transition density for these two variables, $\Phi\left(s_{t+1}|s_t\right)$.[22] The dramatic shifts in the aggregate environment described in the previous section, lead me to choose a specification for $\Phi\left(s_{t+1}|s_t\right)$ that allows for regime switching (e.g., Hamilton, 1994). The main motivation of the regime-switching VAR process is the possibility that the process could change again in the future since it has changed in the past. That is, the rational agents take the structural breaks into account when they forecast. So these changes in the regime can be thought as a random variable rather than deterministic events. The Markov-switching VAR modelling approach also allows the analysts to estimate transition probabilities governing the changes from one regime to another. So the deterministic case can be modeled as an extreme case where the second state is an absorbing state.

Assuming that at any point in time, the economy is in one of the two regimes, the Markov-switching VAR model parameterizes the two regimes as $\left(\beta_o^r, \beta_1^r, \Sigma^r\right)$. When regime $r \in \{1,2\}$ prevails, $s_t = \left[\overline{P}_{F,t}, w_t\right]'$ evolves according to

$$s_t = \beta_o^r + \beta_1^r s_{t-1} + \epsilon_t^r,$$

where $E(\epsilon_t^r \epsilon_t^{r'}) = \Sigma^r$. Switches between regimes are governed by the transition matrix

$$\Pi = \begin{bmatrix} p_{11} & p_{12} \\ p_{21} & p_{22} \end{bmatrix},$$

where $p_{ij},\ i \in \{1,2\}$ is the probability of moving to regime j, given that the economy is currently in regime i.

Notice that one can impose restrictions by allowing only intercept, or intercept and autocorrelation coefficients to be regime dependent. I estimated different model specifications from general (regime dependent intercept, autocorrelation coefficients and covariance matrix) to more restricted ones (regime dependence in some/none of the parameters). The likelihood ratio tests lead me

[22] The details of constructing average import prices are given in the appendix.

to choose the Markov-switching vector autoregressive model with regime dependence in intercept, autocorrelation parameters and variance.[23]

Using the Expectation Maximization Algorithm (the EM algorithm)[24] which is described by Hamilton (1994) I obtain the maximum likelihood estimates reported in Table 4.[25]

Data on import prices are available only annually from United Nations COMTRADE database, so I constructed monthly import prices using a base year industry-specific average import price. Details are given in the appendix. I use monthly manufacturing wages available from the International Labor Organization (ILO).[26] I use monthly data from 1980 through 1998 in the aggregate shock estimation rather than limiting the analysis to the plant-level sample years in order to better identify the two regimes.

The Davies statistic (Table 4) which is applied to test the null hypothesis of linearity (simple VAR) against the alternative of the Markov-switching model indicates that simple VAR can be rejected in favor of Markov-switching VAR with two regimes. So hereafter I will focus on the Markov-Switching VAR results.

The estimated parameters indicate that in the first regime, import prices are about 40 percent lower. The second regime picks up the period between 1984 and 1990 where import prices are higher and more volatile with relatively stable wages. Below I refer to these regimes as relatively open and relatively closed respectively. The transition probabilities indicate that both regimes are persistent. The average duration of regime 1 is about 5.3 years and average duration of regime 2 is about 4.5 years.

Given the transition densities for the aggregate shocks, the next step is estimation of structural

[23]The likelihood ratio tests for the model specification has a non-standard distribution due to the presence of nuisance parameters. I use Davies upper bound which is derived for the significance level of the likelihood ratio test statistics under nuisance parameters.

[24] The EM algorithm is first introduced by Demster, Laird and Rubin (1977) and it is designed for a general class of models where the observed time series depends on some stochastic unobservable variables.

[25]I use the Ox Console MSVAR software package developed by Hans-Martin Krolzig. Details are available at on-line at: http://www.economics.ox.ac.uk/research/hendry/krolzig/.

[26]Monthly wage index is available from 1980 onwards.

parameters.

5.2 Estimation of Structural Parameters

As a first step, I normalize the lower bound of the distribution of sunk entry cost F_L to zero. Furthermore, I assume that entrants draw their initial productivity from a lognormal distribution with mean z which is to be estimated and the variance $\sigma_\mu^2/(1-a_1^2)$. That is, I let entrants draw from a distribution which might differ in mean from incumbents' productivity distribution. I set the discount factor, β, equal to 0.8929 in order to match the average lending rate in Colombia for the period between 1982 and 1991. I set the variance of the foreign varieties, σ_ε^2 equal to 0.9048, which is the variance of the number of 4 digit SITC imported products. In addition, I set the number of exogenous potential entrants that are making entry decision each period, $\overline{R}$, to 90.[27] This leaves me with 14 parameters to estimate. They are the cost parameters, (F_H, f, c_f, x), demand parameters, (α, η, γ), parameters of the production function and productivity process for incumbents and entrants, $(\theta, a_0, a_1, \sigma_\mu^2, z)$ and the foreign market parameter, (N_f). Given the annualized version of stochastic processes for the aggregate shocks, I use the model to estimate remaining parameters.

To estimate the remaining parameters, I embed the dynamic stochastic model defined above in a method of moments estimator. That is, I choose the set of parameters,

$$\delta = \begin{bmatrix} F_H & f & c_f & x & \alpha & \eta & \gamma & \theta & a_0 & a_1 & \sigma_\mu^2 & \sigma_\varepsilon^2 & z & N_f \end{bmatrix}, \tag{13}$$

that minimizes a measure of distance between moments implied by model simulations and their sample counterparts.[28] For any given parameter combination δ, I construct the distance measure as follows. First, using the candidate parameter vector and the estimated values for all of the other

[27]Maximum number of entrants throughout the sample period that I observe in the data is 76. Fixing $\overline{R}$ to different numbers does not affect the results as long as this number is not binding. Identifying $\overline{R}$ would be difficult as the likelihood function would be too flat with respect to entry cost, F_H, and the number of potential entrants, $\overline{R}$.

[28]This is called a method of simulated moments estimator which is first proposed by Lee and Ingram (1990) in a time series model, then Duffie and Singleton (1993) , Hall and Rust (2003) (simulated minimum distance estimator), Gourieroux, Monfort and Renault (1993) (indirect inference).

model parameters, and the initial functional form of H_I mapping on the evolution of industry aggregates, I numerically solve for the value functions (7) & (10). Using the method described above, I simulate a long time series using estimated aggregate shocks and optimal policy functions of the firms. Then I update the parameters of the mapping for the evolution of industry states and solve for the new value functions with updated functional form, until I reach an equilibrium with satisfactory goodness of fit. Then, using the policy functions in combination with randomly drawn aggregate shocks $(\overline{P}_{Ft}, N_{ft}, w_t)$, firm-level productivity shocks (μ_{it}), and entry costs (F), I repeatedly (10 times) simulate patterns of industrial evolution over T periods with some burn-in, where T matches the length of the data sample which is 15.[29] In these simulations, the regime switching process is governed by the estimated probability matrix during the burn-in periods. After the burn-in period, I simulate the aggregate shocks as first five periods spent in regime 1 followed by 10 periods spent in regime 2. A similar pattern is observed in the time series data. I average over these simulations to construct the model moments. In the simulations, I use the same set of randomly drawn errors for each set of parameters. Finally, I calculate the measure of distance between the sample and simulated moments as,

$$X(\delta) = (\boldsymbol{d} - \boldsymbol{m}(\delta))' W (\boldsymbol{d} - \boldsymbol{m}(\delta)), \tag{14}$$

where $\boldsymbol{d}$ and $\boldsymbol{m}$ denote the data and model moments respectively, and W is a conformable matrix of weights.

I calculate the weighting matrix by bootstrapping the data for the first step of estimation. [30]

Simulation based estimators are useful especially for models where the likelihood function is intractable or impossible to formulate as it is in the present model. However, one of the disadvantage

[29]The asymptotic variance of the SMD or SMM estimator is multiplied by a factor (1+1/S) where S is the number of simulations. That means that there is an efficiency gain of running additional simulations because it reduces the variance of the estimator. Variances with only one set of simulations are twice as large as variances when the number of simulations goes to infinity. This increase in the variance might be small compared to the benefit that comes with the significant reduction in the computational burden as noted by Hall and Rust (2003).

[30]I resample the data 500 times. To do that, I assign a plant ID to each plant in the original sample. Then I randomly select the observations from the original data with replacement. If a plant is chosen in particular year then I add the entire time series for this plant to the new sample, so resampling is random across plants but not across time.

is the lack of a formal selection criterion for the appropriate set of moments. Table 5 presents the 20 moments that are used in the estimation.

I use general industry characteristics such as entry and exit rates, expected logarithmic value of the number of operating firms and expected logarithmic value of operating profits in order to identify parameters such as entry cost, scrap value and fixed costs. In addition I use the expected job creation rate through entry and expected job destruction rate through exit to help identify the mean value of entrant's productivity distribution as well as the scrap value. In order to identify firing costs and the persistence of the productivity process, I use four covariance moments and the expected percentage of firms with no change in employment from one year to another.[31] [32]

5.3 Preliminary Estimates

Table 6 reports the preliminary estimation results for the structural parameters.

I estimate the upper bound for the distribution of sunk entry cost, F_H, to be 7,370,000 pesos.[33] Since I normalize the lower bound of the distribution to be 0, this estimate pins down the mean sunk entry cost which amounts to 3,685,000 pesos (100,218 $US). This cost amounts to 19.8% of the average value of total sales in the industry or 87.9% of the average value of the capital. The sunk entry cost covers all the costs that are associated with starting-up a business and that cannot be recovered upon exit. These include government imposed legal costs such as licenses fees, installation and customizing costs, and opportunity cost of managerial time during the set-up period.

The scrap value x is estimated to be 45,000 pesos (1223 $US) per worker. Given the average size of the exiting firms, firms' average scrap value is about 585,000 peso. This value amounts to 14 percent of the average value of the capital in the industry. The net scrap value received after firing costs is on average 277,030 peso which is about 6.6 percent of the average value of capital. Given

[31] Piece-wise linear adjustment costs impose inaction band for past year's employment such that current employment does not change. But since labor is discretized in the model, corresponding the data counter-part has been calculated by looking at the plants with less than 4 percent change from one year to another.

[32] Previous estimation exercises indicate that asymmetric piece-wise linear adjustment costs (hiring and firing costs) cannot be identified together. So I focus on firing costs in the present model.

[33] All values are in 1977 pesos if expressed in pesos or in 1977 USD if expressed in dollar.

the small scale and relatively low capital intensity of the industry, and high exit rate observed in the data, this estimate seems plausible.[34]

The per period fixed cost f is estimated to be 1,032,000 pesos ($US 28,066). Since there is no capital in the production function, this cost reflects all the cost paid to fixed capital and the other per period fixed expenditures which are paid regardless of the production level, such as insurance and mortgage payments. (This cost amounts to approximately 24.6% of the average value of the capital in the industry.)

Firing costs (c_f) are estimated to 23,690 pesos ($US 644) which amounts to approximately 3 months wages. Probably the most significant component of the adjustment costs on firing is the severance payment imposed by the government policies. Seniority payments were significant part of the severance payments. Seniority payments were mandatory in Colombia even in the case of voluntary quits and they amounted to one month salary per year worked based on the salary at the time of separation.

Estimated productivity process parameters indicate that the productivity process is persistent and but highly volatile, with root 0.8987, and with variance, 0.229. If the persistence of productivity shocks is very high, firms expect that jobs created today will be around for a long time, so the effect of firing costs on the hiring propensity will be lower. Since the estimated persistence parameter is not very high, and the variance is high, the mitigation effect of labor adjustment costs on firms' employment decisions is limited. For the same sample period the persistence of productivity process is estimated about 0.93 in the Colombian Apparel Industry by Bond et al. (2006). Since bigger firms usually shows higher persistence on average, the lower size of Metal Products Industry compared to Apparel Industry makes this estimate plausible. The intercept term for the entrants' productivity distribution is estimated to be 0.084 which is lower than the corresponding term of incumbents' productivity, 0.091. This estimate indicates that entrants are on average less productive than incumbent firms and that net entry dampens productivity growth. The estimate of the returns to scale parameter is 0.489 which seems plausible.

[34]Caves and Porter (1976) argue that capital-intensive industries and industries with a large average firm size exhibit strong barriers to exit.

The estimate of α is 6479 and that of η is 0.465.[35] Parameter γ, which is the index for the substitutability among the differentiated goods, is 0.215. This estimate is at the same time the slope of the demand curve that each domestic firm faces. The implied average demand elasticity is by about 10.5.

Table 5 shows how well the model performs in fitting the data. The model performs fairly well in matching the key industry moments such as mean employment, mean and variance of operating profit, and mean number of operating firms. It does over-estimate import-penetration rate. Although it under-estimates entry and exit rate, it is possible that linkage problems in the data set cause some artificial increase in entry and exit rates.

6 Preliminary Simulation Results

Given all the estimated parameters, I next conduct several experiments to quantify the effects on the import-competing industry of changes in the economic environments. First, I use the estimated switching model to simulate industrial evolution and job flow patterns in an environment that bumps stochastically between the relatively inward-oriented and the relatively open regime according to the estimated regime switching probabilities. Firms correctly perceive the current regime, and the regime-specific transition densities for the aggregate shocks that are reported in Table 4.

In this experiment, using the discretized version of the MSIAH model, I first solve the industrial evolution model and find the equilibrium transition density for industry aggregates as well as the optimal decisions. Then, given the simulated path for the aggregate shocks, I simulate 100 trajectories for 20 period years with 20 burn-in period years and take the averages over those trajectories.

The exercise reported in Table 7 and Table 8 compares average industry characteristics during the relatively open regime with average characteristics during the relatively closed regime. Thus, for both types of statistics, I am describing performance in the aftermath of a regime switch rather than

[35] Standard errors of both α and η indicate these two parameters are not significant. There might be an identification issue. This will be a point of future consideration.

the long run effects. This comparison will give insights into the short-run, transitionary dynamics of the model.

The model predicts that switching to the regime with low import prices is associated with a significant (18 percent) reduction in the number of jobs (Table 7). The actual reduction in the total employment averages from the period 1982-1990 to 1991-1998 is about 22 percent, thus the model does a good job of predicting the employment response of the industry. A potential reason for this slight undershooting could be that the average number of foreign varieties do not change across regime in this version of the model. The new version of the model which incorporates the regime specific number of foreign varieties is under development.

The number of active firms also drops by roughly 11 percent, so a substantial fraction of the total reduction in jobs is due to net exit. More precisely, the percentage of job loss through exit is about 41 percent in the more liberal trade regime. Thus the model provides a structural explanation for the stylized fact that significant job destruction takes place on the entry/exit margin, and it suggests that studies based on panels of continuing firms are likely to miss a fundamental type of job flow.

Because exit takes place disproportionately at the low end of the productivity distribution, there are also productivity gains associated with the switch to a more liberal trade regime. The average un-weighted productivity of incumbents increases 0.079 log points. The average size weighted productivity increases by about 0.004 log points. That is, as competition becomes tougher, the threshold level of productivity below which staying out is more profitable increases. This, too, is consistent with econometric studies that show productivity gains in the aftermath of a trade liberalization due to the exit of inefficient firms (e.g., Liu (1993), Pavcnik, (2002), Eslava, et al.,(2007)).

Although plants that survive under the new regime are on average more productive, they produce at a smaller scale. Specifically, the average size of firms decreases by 15 percent. These results are also supported by the econometric evidence that plants contract in the face of import competition (Head and Ries, (1999)).

The demand intercept that domestic firms face depends on both the total number of firms, domestic and foreign, and on the average price. The decrease in the average price of imported goods shifts down the demand that domestic firms face. Due to the corresponding decrease in the number of domestic firms, the demand curve shifts upward, but the net effect is negative. The demand elasticities that domestic firms face, on the other hand, decrease despite of the downward shift of the demand curve. This is because firms are now more productive on average, and so marginal costs are now lower. Thus, although profits are lower by about 20 percent on average, firms charge higher mark-ups as the selection effect on firms with higher productivity outweighs the effect of increased competition on firms' mark-ups.

Average demand elasticities decrease by about 20 percent from 11.62 to 9.19. The empirical evidence on the impact of trade liberalization on mark-ups is mixed. This result is in line with e.g. Thompson (2000) who finds a positive relationship between mark-ups and import competition in Canadian manufacturing industries, but in contrast to e.g. Levinsohn (1993) who finds evidence of decreasing mark-ups after trade liberalization in Turkey. Welfare can be calculated using the indirect utility function associated with equation 3. Assuming the consumer's income to be zero for simplicity, the associated welfare figure in the relatively open regime is 44682.4 versus 53326.1 in the high import price regime. [36]

Together, these results confirm that the model developed here is capable of predicting the actual industry outcomes and replicating the patterns of correlation familiar from other studies. But since the underlying structure that generates these patterns is also modeled, it is possible to perform counterfactual experiments.

6.0.1 Transition and Severance Payments

Figures 3(a) and 4(a) show evolutions of un-weighted productivity of incumbents and the average un-weighted productivity of exiting firms. In these figures, the dotted vertical red line indicates

[36] With regard to these numbers, it should be considered that variance of prices among the foreign varieties is not taken into account and that the model assumes that the number of foreign varieties does not change across regimes. This implies a fairly large amount of decrease in the number of total varieties induced by net exit in the low import price regime. Although this assumption can be justified with the presence of export costs and a negligible share of the industry in the world market, it is a point of consideration.

the time when the macro regime switches from a high import price regime to a low one. Two cases are considered, the benchmark case (blue line) and the case where the firing costs are lowered by 1 months wage (red line). In these simulations, I started with the same underlying distribution of firms, Γ, in both cases. They are simulation averages of 40 trajectories. Net exit is one important source of productivity gain, specifically the un-weighted productivity average of exiting firms increases from -0.81 to -0.64 by about 18 percent.

Despite of the significant increase in the productivity average of exiting firms, and the corresponding increase in the un-weighted productivity average of incumbents, the covariance between size and productivity (in Figure 3(b)) decreases significantly for the first few years of the transition in both economies and then continue to be lower on average than the high import price regime. This is because the high import price regime exhibits significantly more persistence, and so switching to a less persistent macro regime induces a higher inaction band in employment decisions of the firms as firms perceive jobs created today will less likely be here tomorrow. More specifically, in the relatively open regime, in 46184 states out of 100800 discrete states, firms do not adjust their employment decisions. In the high import price regime, on the other hand, in 44766 discrete states out of 100800 firms do not adjust their employment decisions.

At year 1, the covariance in the lower firing costs case starts at a higher level than the benchmark although the underlying Γ is the same. This is because employment decisions are less distorted in the low firing costs economy in the sense that the invariance band that is induced by the firing costs is smaller. More precisely, covariance is 0.970 on average throughout the 15 year-periods in the benchmark whereas the covariance is 0.995 on average in the low firing costs economy. Due to delays in the size adjustment decisions of big firms, together with the delays of the exit decisions of relatively inefficient big firms, the covariance in both economies dips in the first couple of years of the transition.

Looking at the employment effect of the reduction in the firing costs during the transitionary periods, lower firing costs has a slightly negative effect on the total employment. The total number of jobs decreases from 3969 to 3986 on average during the first 10 years of the low import price regime. The average total number of active firms is slightly higher during the transitionary periods in the low firing costs economy. This implies that an adjustment is more on the exit margin rather than the contraction margin in high firing costs economies during the liberalization episodes. The figure 4(c) also shows the evolution of actual employment in the industry between 1987 till 1998. Since the trade liberalization was in 1991, I place the actual data such that regime switch coincides with 1991. One difference between the actual data and the model simulations is that, the model simulations show sharper immediate response to more liberal trade regime. Following a sharp decline both the model and the data have similar recovery patterns.

This exercise sheds light on the role of severance payments in the transition to a more liberal trade regime and the results show that firing costs have significant negative effects on the productivity of firms as well as the relationship between productivity and size. The impact on total employment of lowering firing costs from 3 months wages to 2 months wages is, however, quite limited. These results provide a rationale for the common practice of reforming labor market codes before trade liberalization. They also shows that patterns of macro regimes are important determinants of the extent of productivity gain/loss that can be obtained by labor market reform. To examine the long-run effect of severance payments, the next exercise compares the long-run statistics of the two industries.

6.0.2 Job Flow Patterns

Figure 5 shows job flow patterns in the model simulations which are averages over 40 trajectories both in the benchmark and in the low firing costs economy. Given one set of evolution of regime, I simulated 40 trajectories and take the averages over those trajectories. Year 5 is the year where the industry switches from being in a relatively closed regime to being in a relatively open one. As a general trend, in the sample data, job creation is more responsive to shocks than job destruction. That is, job creation differs more between booms and recessions than job destruction does. This is in contrast to a general trend observed in data for developed countries (Davis, Haltiwanger, Schuh (1997)). One potential reason is the presence of heavy labor market regulations on firing in developing countries as in the case of Colombia. The model does a good job of replicating this pattern of the data; in the model too, job creation is more sensitive to recessions and booms than job destruction is. The correlation coefficient between job creation and net employment growth is 91 percent and the correlation between job destruction and net employment growth is about 73 percent. These numbers are 83 and 35 respectively for the sample data.

The model does a fairly good job replicating the extent of the job flows through expansion, contraction and entry. It does slightly under-shoot the exit as it does not replicate the occasional exit of a few large plants that exit for reasons that are not modeled in the present paper.

6.1 Severance Payments in the Long Run

The impact of labor adjustment costs on aggregate employment and productivity has received considerable attention in the literature. Table 9 reports the simulation averages of the industry aggregates in the benchmark where industry stochastically jump between the relatively open and the relatively closed environment and in a hypothetical economy when the severance payments are decreased from 23,690 1977 peso to 15,690 1977 peso. I simulate both these economies over 40 periods using the Markov-Switching VAR process, repeat 40 times and take averages of the industry moments. I use the same set of random shocks both in the benchmark case and in the hypothetical case with lower severance payments. The immediate effect of lowering firing costs is to increase the rate of job destruction. But it also increases the hiring propensity of firms, and the net effect is positive with approximately 0.018 log point increase in the average size of the firms and 2 percent increase in the total number of jobs.

The size weighted log productivity increases by about 0.8 percent. There are two sources of the productivity change. One is the increased turnover rate and the other is the market share reallocation among incumbents. Firing costs distort efficient market share reallocation as it delays the response of firms to the idiosyncratic and aggregate shocks. As a result, the covariance between size and productivity increases by about 2 percent with one months wage reduction in the firing costs. Increase in the turnover rate works in the same direction, as entering firms are relatively more productive than exiting firms. Note that increase in the net entry works in the opposite direction, that is, net entry decreases aggregate productivity as entering firms are relatively less productive than incumbents. Despite an about 21 percent increase in the job destruction rate, a 8,000 peso reduction in severance payments lowers the total average layoff costs by about 2,648,000 peso.

This exercise shows that severance payments have significant negative effect on aggregate employment and productivity, but the effect on productivity is more pronounced when we look at the transition years towards a low import price regime.

7 Concluding Remarks and Future Work

In this paper I build and estimate a dynamic industrial evolution model with import competition where heterogeneous firms adjust their employment levels in response to each others' behavior and to the degree of foreign competition. Preliminary counterfactual experiments establish the link between the macroeconomic environment and the response of the industry to greater openness. Additional experiments in progress include the role of expectations in regime sustainability and the impact of exchange rate volatility.

Exporting opportunities becoming available with trade liberalization is one important channel in the selection process. Relatively efficient firms in the domestic market gain access to the foreign markets and increase their market. In this paper I do not consider export and so apply the model developed to an industry where firms mostly service the domestic market. Adding export to the model is one important future extension envisioned.

Productivity gain in the model emphasizes the selection channel, which is empirically shown to be a very important source of the aggregate productivity after trade liberalization. But another channel which might also be important is intra-firm productivity gain. Intra-firm productivity is taken as an exogenous process in the model, so it would be interesting to endogenize intra-firm productivity process, through e.g. technology adoption or imported intermediate goods.

References

[1] Bentivogli C. and P. Pagano (1999), "Trade, Job Destruction and Job Creation in European Manufacturing," *Open Economies Review* 78: 165-184.

[2] Bentolila, S. and G. Bertola (1990), "Firing Costs and Labor Demand: How Bad is Eurosclerosis?," *Review of Economic Studies* 57: 381-402.

[3] Bernard, A. B., J. Eaton, J. B. Jensen and S. Kortum (2003),""Plants and Productivity in International Trade," *American Economic Review,* 93: 1268-1290.

[4] Bernard, A. B., J.B. Jensen, and P.K. Schott (2005), "Survival of the Best Fit: Exposure to Low-Wage Countries and the (Uneven) Growth of U.S. Manufacturing Plants", *Journal of International Economics*, forthcoming.

[5] Bond, R., J. Tybout, and H. Utar (2005), "Industrial Evolution in Crisis-Prone Economies," Mimeo: Pennsylvania State University

[6] Burgess, S. and M. Knetter (1998), "An International Comparison of Employment Adjustment to Excahange Rate Fluctuations", *Review of International Economics* 6:151-163.

[7] Cameron, S., S. Chaudhuri, and J. Mclaren (2004), "Mobility Costs and the Dynamics of Labor Market Adjustments to External Shocks: Theory," Working paper.

[8] Chamberlin, E. (1933), *Theory of Monopolistic Competition*, Cambridge, Mass: Harward University press.

[9] Chaudhuri, S. and J. McLaren (2003), "The Simple Analytics of Trade and Labor Mobility I: Homogeneus Workers," Working paper.

[10] Cooper, R., J. Willis, and J. Haltiwanger (2004), "Dynamics of Labor Demand: Evidence from Plant Level Observations and Aggregate Implications," *NBER Working Paper # 10297*

[11] Das, M., M. Roberts, and J. Tybout (2007), "Market Entry Costs, Producer Heterogeneity, and Export Dynamics", *Econometrica*, 75(3): 837-873.

[12] Davidson, C. and S. Matusz , "Trade and Turnover: Theory and Evidence," *Review of International Economics*, forthcoming.

[13] Davidson, C., L. Martin, and S. Matusz (1999), "Trade and Search Generated Unemployment," *Journal of International Economics*, 48: 271-299.

[14] Davis, S., Haltiwanger, J., and S. Schuh (1997),*Job Creation and Destruction*, Cambridge, MA, The MIT Press.

[15] Dempster, Laird and Rubin (1977), "Maximum Likelihood from Incomplete Data via the EM Algorithm, " *Journal of the Royal statistical Society* Series B

[16] Ericson, R. and A. Pakes (1995),"Markov-Perfect Industry Dynamics: A Framework for Empirical Work", *Review of Economic Studies*, 62: 53-82.

[17] Erdem, E. and J. Tybout (2003),"Trade Policy and Industrial Sector Responses: Using Evolutionary Models to Interpret the Evidence",*Brookings Trade Forum*

[18] Eslava, Haltiwanger, Kugler, Kugler (2007),"Trade Reforms and Market Selection: Evidence From Manufacturing Plants in Colombia," working paper.

[19] Fajnzylber, P. and W. Maloney (2000), "Labor Demand and Trade Reform in Latin America," *World Bank Policy Research Paper* #2491.

[20] Foster, L., J. Haltiwanger, and C. Syverson (2007), "Reallocation, Firm Turnover and Efficiency: Selection on Productivity or Profitability?"

[21] Freeman, R., and L. Katz (1991), "Industrial Wage and Employment Determination in an Open Economy," in *Immigration, Trade and Labor Market*, edited by J. M. Abowd and R. B. Freeman. Chicago: University of Chicago Press.

[22] Gourinchas, P.0. (1999), "Exchange Rates Do Matter: French Job Reallocation and Exchange Rate Turbulence 1984-1992," *European Economic Review*, 43: 1279-1316.

[23] Goldberg, P. and M. M. Knetter (1997), "Goods prices and Exchange Rates: What Have We Learned?," *Journal of Economic Literature* 35: 1243-1272.

[24] Gouriéroux, C., and A. Monfort (1996), *Simulation-Based Econometric Methods*, Oxford University Press Inc., New York.

[25] Hamilton, J. D. (1990), "Analysis of Time Series Subject to Changes in Regime," *Journal of Econometrics*, 45: 39-70.

[26] Hamilton, J.D. (1994), *Time Series Analysis*, Princeton, NJ: Princeton U. Press.

[27] Head, K. and Ries, J. (1999), "Rationalization Effects of Tariff Reductions," *Journal of International Economics*, 47: 295-320.

[28] Heckman, J. and C. Pagés (2000), "The Cost of Job Security Regulation: Evidence from Latin American Labor Markets," *NBER Working Papers* # 7773

[29] Heckman, J. and C. Pagés (2003), "Law and Employment: Lessons from Latin America and Caribbean," *NBER Working Papers* # 10129

[30] Hopenhayn, H. (1992), "Entry, Exit and Firm Dynamics in Long Run Equilibrium," *Econometrica* 60(2):1127-1150.

[31] Hopenhayn, H. and R. Rogerson (1993), "Job Turnover and Policy Evaluation: a general equilibrium analysis," *Journal of Political Economy* 96: 593-617.

[32] Kambaurov, G. (2003), "Labor Market Restrictions and the Sectoral Reallocation of Workers: The Case of Trade Liberalizations,"Mimeo: University of Toronto.

[33] Khan, A. and J. Thomas (2003), "Nonconvex factor Adjustments in Equilibrium Business Cycles Models: Do Nonlinearities Matter?," *Journal of Monetary Economics* 50: 331-360.

[34] Klein, Triest and Schuh (2003), "Job Creation, Job Destruction and Real Exchange Rate," *Journal of International Economics*, 59:

[35] Kolda, T.G., R. M. Lewis, and V. Torczon (2003), "Optimization by direct search: New perspectives on some classical and modern methods," *SIAM Review*, 45: 385-482.

[36] Krusell, P. and A. Smith (1998), "Income and Wealth Heterogeneity in the Macroeconomy," *Journal of Political Economy* 106:867-896.

[37] Kugler, A. D. (2005), "Wage-shifting effects of severance payments savings accounts in Colombia," *Journal of Public Economics* 89: 487-500.

[38] Levinsohn, J. (1999), "Employment responses to international liberalization in Chile," *Journal of International Economics* 47: 321-344.

[39] Levinsohn, J. (1999), "Employment responses to international liberalization in Chile," *Journal of International Economics* 47: 321-344.

[40] Levinsohn, J. (1993),"Testing the imports-as-market-discipline hypothesis", *Journal of International Economics* 35:1-22.

[41] Liu, L. (1993), "Entry-Exit, Learning and Productivity Change: Evidence from Chile," *Journal of Development Economics* 42: 217-242.

[42] Melitz, M. and G. Ottaviano (2005), "Market Size, Trade and Productivity," NBER Working Paper # 11393

[43] Melitz, M. (2003), ""The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica* 71: 1695-1725.

[44] Ottaviano, G., T. Tabuchi, and J. Thisse (2002),"Agglomeration and Trade Revisited," *International Economic Review*, 43: 409-436

[45] Pakes, A. P. McGuire (1994),"Computing Markov-Perfect Nash Equilibria: Numerical Implications of a Dynamic Differentiated Product Model", *Rand Journal of Economics*, 25(4):555-589.

[46] Pavcnik, N. (2002) "Trade Liberalization, Exit and Productivity Improvements: Evidence from Chilean Plants," *Review of Economic Studies* 69, pp. 245-76.

[47] Revenga, A. L., (1992), "Exporting Jobs? The Impact of Import Competition on Employment and Wages in U.S. Manufacturing," *Quarterly Journal of Economics* 107, 255-284.

[48] Revenga, A. L., (1997), "Employment and Wage Effects of Trade Liberalisation: The Case of mexican Manufacturing," *Journal of Labor Economics*, 15, 520-543.

[49] Rodriguez, F., and D. Rodrik (2000), "Trade Policy and Economic Growth: A Skeptic's Guide To The Cross-National Evidence,", Working Paper.

[50] Sachs, J.D., H. J. Shatz (1994), "Trade and Jobs in U.S. Manufacturing," *Brooking Papers on Economic Activity* 1994, 1-65

[51] Tauchen, G. and R. Hussey (1991),"Quadrature-Based Methods for Obtaining Approximate Solutions to Nonlinear Asset Pricing Models," *Econometrica*, 59: 371-396.

[52] Thompson, A.J. (2000), "Import Competition and Market Power: Canadian Evidence," Analytical Studies Research Paper Series 11F0019MIE2000139, Analytical Studies Branch. Ottawa: Statistics Canada.

[53] Tybout, J. and Westbrook, M. (1995),"Trade Liberalization and the Dimensions of Efficiency Change in Mexican Manufacturing Industries", Journal of International Economics, 39, 53-78.

[54] Veracierto, M. (2001), "Employment Flows, Capital Mobility and Policy Analysis," *International Economic Review* 42: 571-595.

8 Appendix

8.1 Construction of Industry Specific Average Imported Goods Prices

Average imported good prices are constructed as follows:

$$\overline{P}_{F,t} = DP_{F,t}(1+\tau_t)(\frac{e_t}{P_t^{CPI}}), \tag{15}$$

where $DP_{F,baseyear}$ denotes the average price of imported varieties in dollar term, τ_t denotes the tariff rate for the four digit industry, e_t denotes the nominal exchange rate, P_t^{CPI} denotes the consumer price index at period and subscripts t denotes the time. Notice that the real exchange rate variation is going to be picked up by the last term, $\frac{e_t}{P_t^{CPI}}$.

8.2 Computational Issues

8.2.1 Discretization

In the model, productivity process and the process that governs evolution of aggregate shocks are discretized using the Gaussian quadrature nodes as described in Tauchen and Hussey (1991). Productivity process is estimated using 6 discrete points. The model results did not show sensitivity with increasing number of discrete points for the productivity process. The transition density for aggregate shocks is estimated using Markov switching technique. There are two VAR processes that corresponds the two regimes and transition probabilities that govern regime switching. In order to discretize this process, I use total 8 discrete points, 4 for regime 1 and 4 for regime 2. For each regime I use 2 discrete points for import prices and 2 for wages. Notice that regime variable becomes a state variable in this case.

Firms dynamic optimization problem is solved by computing an approximation to the value function on the grid points. The resulting endogenous aggregate state variables are not restricted to being on the grid, and corresponding policy decisions are computed using cubic spline interpolation techniques.

8.2.2 Optimization Routines

Simulated annealing routines together with pattern search algorithms are used in the estimation of structural parameters. Simulated annealing optimization algorithm imitates the annealing process by controlling the search using temperature parameter that starts from a high temperature and it lowers/ cool down at each iteration with an improvement of the value of the objective function. This algorithm also accepts points which do not improve the objective so as not to trap into local minima where the probability of doing so depends on the value of the temperature.

Table 1: Import and Export in Colombian Metal Products Industry

	1979	**1984**	**1985**	**1988**	**1991**
Export Orientation Ratio	0.05	0.012	0.021	0.06	0.07
Import Penetration Ratio	0.19	0.27	0.17	0.22	0.27

Source: DANE and COMTRADE, author's calculation.

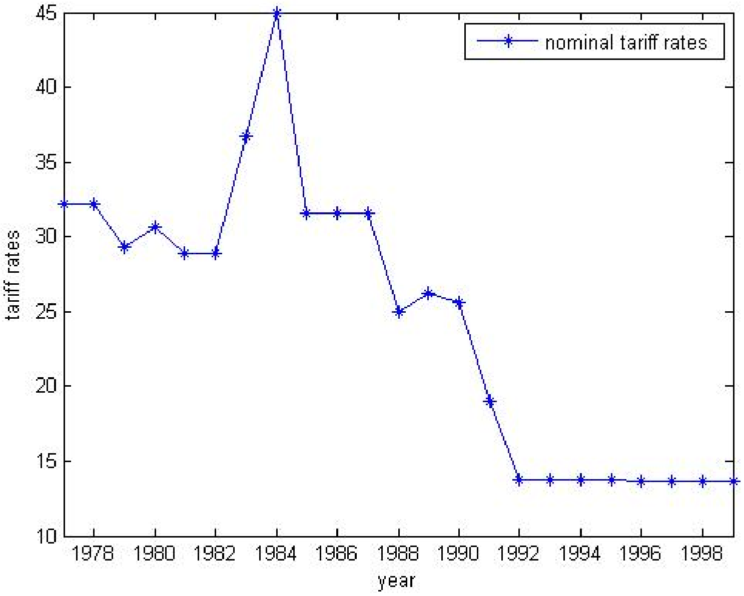


Figure 1: Nominal Tariff Rates for the Structural Metal Products Industry (SIC 3813), Source: DANE

Table 2: Job Creation and Destruction in Colombian Metal Products Industry

Year	**Expansion**	**Contraction**	**Entry**	Exit
	$((E_t - E_{t-1})/L_{t-1})$	$((C_t - C_{t-1})/L_{t-1})$	(B_t/L_{t-1})	(D_{t-1}/L_{t-1})
1978	0.213	-0.028	0.091	-0.076
1979	0.077	-0.064	0.064	-0.063
1980	0.057	-0.045	0.077	-0.078
1981	0.129	-0.050	0.086	-0.136
1982	0.071	-0.136	0.076	-0.087
1983	0.045	-0.047	0.058	-0.318
1984	0.073	-0.063	0.338	-0.197
1985	0.018	-0.103	0.138	-0.081
1986	0.249	-0.033	0.014	-0.135
1987	0.032	-0.132	0.013	-0.041
1988	0.070	-0.065	0.125	-0.064
1989	0.155	-0.035	0.040	-0.060
1990	0.044	-0.107	0.021	-0.068
1991	0.027	-0.119	0.047	-0.054

Source: DANE, author's calculation.

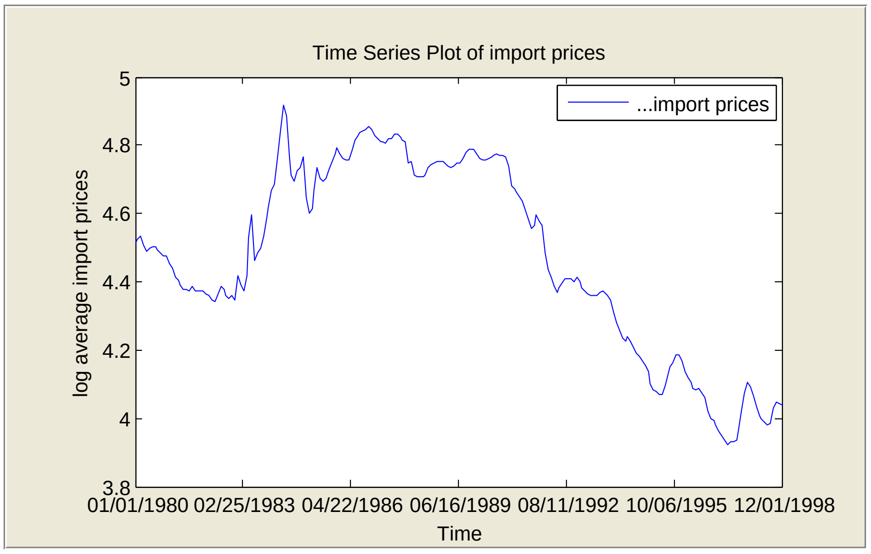


Figure 2: Average Import Prices in Metal Products

Table 3: Net and Gross Flows in the Sample Data

	Net Change			Gross Turnover		
Year	$\left(\frac{E_t - E_{t-1}}{L_{t-1}} + \frac{C_{t-1} - C_t}{L_{t-1}}\right)$	$\left(\frac{B_t}{L_{t-1}} + \frac{D_{t-1}}{L_{t-1}}\right)$	**Total**	$\left(\frac{E_t - E_{t-1}}{L_{t-1}} + \frac{C_{t-1} - C_t}{L_{t-1}}\right)$	$\left(\frac{B_t}{L_{t-1}} + \frac{D_{t-1}}{L_{t-1}}\right)$	**Total**
1978	0.185	0.015	0.200	0.241	0.168	0.408
1979	0.013	0.001	0.014	0.141	0.127	0.269
1980	0.012	-0.001	0.012	0.101	0.156	0.257
1981	0.079	-0.050	0.029	0.179	0.222	0.401
1982	-0.065	-0.011	-0.076	0.208	0.162	0.370
1983	-0.002	-0.260	-0.262	0.091	0.377	0.468
1984	0.010	0.141	0.150	0.136	0.535	0.670
1985	-0.085	0.056	-0.029	0.121	0.219	0.340
1986	0.216	-0.120	0.096	0.283	0.149	0.432
1987	-0.100	-0.029	-0.128	0.164	0.054	0.218
1988	0.005	0.062	0.067	0.134	0.189	0.324
1989	0.120	-0.021	0.100	0.190	0.100	0.290
1990	-0.064	-0.048	-0.111	0.151	0.089	0.240
1991	-0.093	-0.007	-0.100	0.146	0.101	0.247

Source: DANE, author's calculation.

Table 4: Parameters of the MS-VAR models

	Wage	Price
Intercept β_0^1(regime 1)	1.922979 (0.3296)	0.447000 (0.1493)
Intercept β_0^2 (regime 2)	0.052081 (0.1520)	-0.894257 (0.5112)
AR coefficients β_1^1 (regime 1)	0.513143 (0.0819)	-0.084700 (0.0376)
	-0.014908 (0.0083)	0.970000 (0.0037)
AR coefficients β_1^2 (regime 2)	0.990542 (0.0410)	0.289291 (0.1377)
	-0.003526 (0.0050)	0.953829 (0.0175)
Covariance matrix Σ^1(regime 1)	4.5240e-4	-1.5667e-5
	-1.5667e-5	9.5084e-5
Covariance matrix Σ^2 (regime 2)	1.2329e-4	6.0883e-5
	6.0883e-5	1.5470e-3
Switching probabilities Π	0.9842	0.0158
	0.0185	0.9815
Log Likelihood	1135.8398	
LR Linearity Test	224.4336	
DAVIES	0.0000**	

Data source: ILO, UN COMTRADE, Banco de la Repblica de Colombia, and Secretaria Distrital De Planeacion. Standard deviations are in parentheses.

Table 5: Model Fit

	Simulated Moments	**Sample Moments**
Expected Value of Labor	3.111	3.094
Variance of Log Labor	0.7658	1.060
Expected Value of Log Profit	6.9598	6.968
Variance of Log Profit	2.4907	2.3630
Expected Growth in Labor	0.015	-0.014
Variance of Growth in Labor	0.1049	0.0860
Expected Entry Rate	0.1633	0.2110
Expected Exit Rate	0.1641	0.2200
Variance of Entry Rate	0.0042	0.011
Variance of Exit Rate	0.0072	0.0140
Covariance of Log Labor and Lagged Log Labor	1.0613	0.9874
Covariance of Log Labor and Log Profit	1.2178	1.1846
Covariance of Labor Growth and Log Profit	-0.035	0.020
Covariance of Labor Growth and Log Labor	-0.0923	0.048
Expected Log Number of Firms	5.0777	5.016
Variance of Log Firms	0.0408	0.0330
Expected % of Firms with No Change in Employ.	0.240	0.230
Expected Import Penetration Rate	0.5189	0.254
Expected Job Creation Rate Through Entry	0.0883	0.0850
Expected Job Destruction Rate Through Exit	-0.0614	-0.1040

Table 6: Estimated Cost and Demand Parameters for the Colombian Metal Products Industry

	Parameters	**Standard Errors**
Sunk Entry Cost (Upper Bound) (F_H)	7370 *	97.1423
Fixed Cost, f	1032*	7.6165
Scrap Value,x	45*	5.2782
Firing Cost, c_f	23.69*	0.4193
Demand Parameter, α	6479	12014
Demand Parameter, η	0.465	1.4569
Demand Parameter, γ	0.215	0.0079
Production Function Parameter	0.489	0.0062
Incumbents' Productivity Process, intercept ($a_{0\mu}$)	0.0918	0.0004
Incumbents' Productivity Process, root, ($a_{1\mu}$)	0.8987	0.0005
Incumbents' Productivity Process, variance (σ^2_μ)	0.229	0.0115
Entrants' Productivity Distribution,mean (z)	0.085	0.0034
Number of Imported Varieties Nf	84	1.7993

*In thousand 1977 pesos.

Table 7: Industry Performance-Summary Statistics

	Relatively Open Regime (Regime 1)	**Relatively Closed Regime** (Regime 2)
Total Employment	3695	4518
Mean Job Creation Rate	0.1157	0.2177
Variance Job Creation Rate	0.0010	0.0108
Mean Job Destruction Rate	-0.1797	-0.1243
Variance Job Destruction Rate	0.0017	0.0006
Mean Productivity of Incumbents (Log Solow Residual)	0.7480	0.6689
Mean Size Weighted Productivity	1.1570	1.1526
Mean Number of Firms	140.55	158.03
Mean Entry Rate	0.1518	0.1792
Mean Exit Rate	0.1791	0.1538

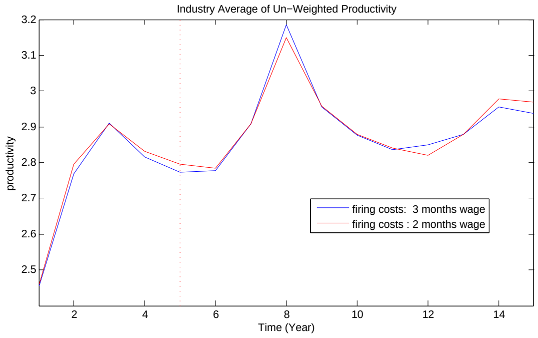
Table 8: Industry Performance-Summary Statistics

	Relatively Open Regime (Regime 1)	**Relatively Closed Regime** (Regime 2)
Mean Log Operating Profit	6.8725	7.0789
Variance Log Operating Profit	1.6749	2.7942
Mean Log Size	2.9617	3.1099
Variance Log Size	0.6427	0.9036
Mean Demand Elasticity	9.1914	11.6248
Mean Import Price	60.8835	92.7303
Variance Average Import Price	0.2751	10.5667
Mean Domestic Price	74.6782	102.2721
Variance Average Domestic Price	1.8487	10.3042

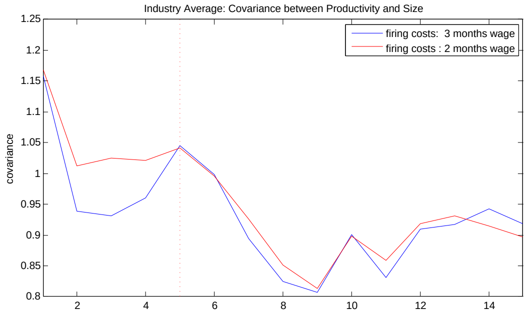
Table 9: Industry Performance-Summary Statistics: Long Run

	(2 months wage firing)	**(3 months wage firing)**
Mean Log Size	3.0602	3.0415
Variance Size	0.6527	0.7653
Mean Profit	7.3277	6.9877
Variance Profit	1.1082	2.1928
Mean Number of Firms	150.54	147.10
Mean Total Employment	4179.2	4089.9
Mean Size Weighted Productivity of Incumbents	3.8261	3.7939
Mean Covariance Between Size and Productivity of Incumbents	1.0161	0.9969
Mean Entry Rate	0.1651	0.1637
Mean Exit Rate	0.1694	0.1678
Mean Job Creation	0.1951	0.1575
Mean Job Destruction	-0.1860	-0.1534
Mean Total Layoff Costs	12311†	14959†

†In thousand 1977 pesos.

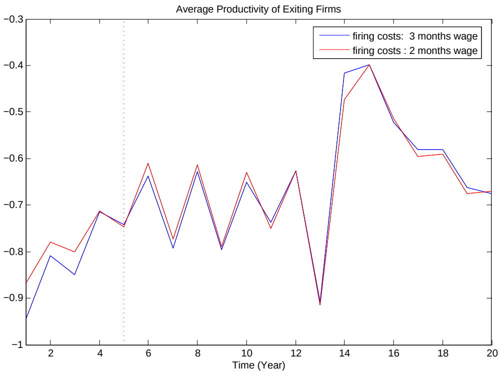


(a) Productivity of Incumbent Firms

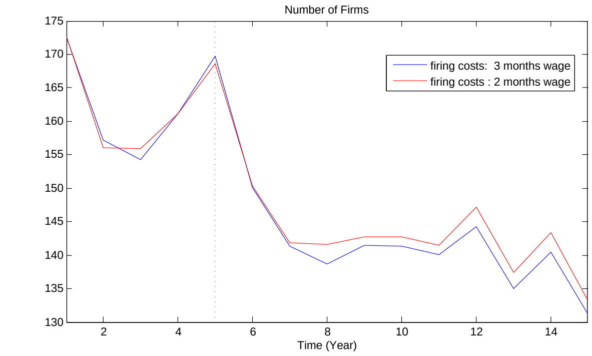


(b) Covariance of Productivity and Size

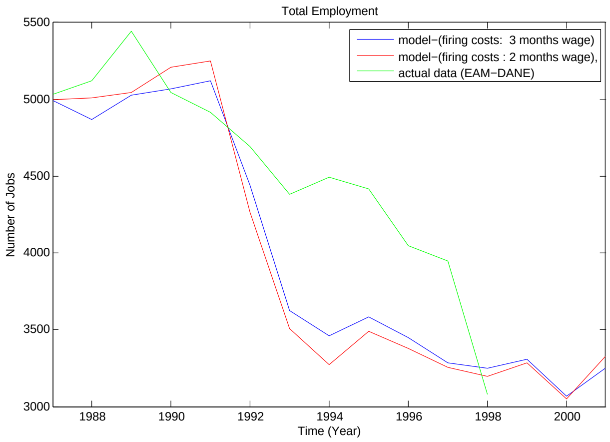
Figure 3: Transition periods in the Model Simulations: The Impact of Firing Costs on Productivity



(a) Productivity of Exiting Firms



(b) Total Number of Firms



(c) Aggregate Employment

Figure 4: Transition Periods in the Model Simulations: The Impact of Firing Costs on Employment

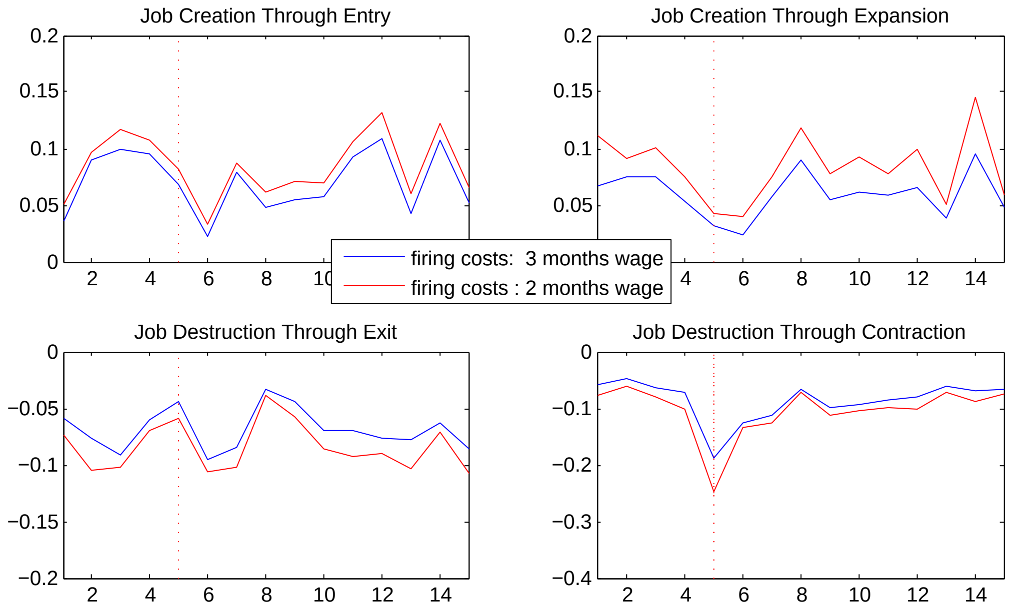


Figure 5: Transition periods in the Model Simulations: Job Flows